

Additions to the distribution of Sudanese scorpions

Manal Siyam¹, Jason A. Dunlop², František Kovařík³, Abubakr Mohammad^{4,5}

¹ University of Khartoum, Faculty of Science, Sudan Natural History Museum, Al-Jamaa Avenue, P.O Box 321, Khartoum, Sudan

² Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity, Invalidenstraße 43, D-10115 Berlin, Germany

³ Charles University, Department of Zoology, Viničná 7, CZ-128 44 Praha 2, Czech Republic

⁴ Independent researcher, Natural Heritage, Sudan

⁵ Current address: Flat 4, 19 Byram Street, Huddersfield, HD1 1DR, UK

<https://zoobank.org/B9F5B3C5-9F01-4D66-B542-2850719DEBEA>

Corresponding author: Jason A. Dunlop (jason.dunlop@mfng.berlin)

Academic editor: Danilo Harms ♦ Received 26 July 2022 ♦ Accepted 25 November 2022 ♦ Published 6 January 2023

Abstract

Six species of scorpion (Arachnida: Scorpiones) are documented from eighteen localities in seven different states within the Republic of the Sudan. Combining this new data with historical records in the Sudan Natural History Museum and the published literature enables the first provisional distribution maps for Sudanese scorpions. New state records could be added for three medically significant species: *Androctonus amoreuxi* (Audouin, 1826) from Khartoum, North Kordofan and North Darfur, *Leiurus quinquestriatus* (Ehrenberg, 1829) from Kassala, River Nile, White Nile and North Darfur, and *Parabuthus abyssinicus* (Pocock, 1901) from Kassala. Among the less venomous species, we offer new state records for *Buthacus leptochelys* (Ehrenberg, 1829) in White Nile State, for *Compsobuthus werneri* (Birula, 1908) in North Kordofan, White Nile and Kassala States and for *Orthochirus olivaceus* (Karsch, 1881) in River Nile, Northern and Kassala States. Further information about the taxonomy, distribution and toxicity of Sudanese scorpions is presented.

Key Words

distribution, East Africa, identification, public health, Scorpiones

Introduction

Scorpions are a familiar group of arachnids found in warmer regions of the world, including throughout Africa. The Republic of Sudan covers a huge area of eastern Africa and is of particular biogeographical interest for hosting a range of environments (Fig. 1), including deserts in the north and west, coastal regions in the east, the Nile valley, and subtropical savannahs to the south. Despite this size and diversity of habitats, Sudan's scorpion fauna remains rather poorly known. Notable early accounts include Hirst (1911a, b), Werner (1911), King (1925) and Borelli (1929). These, and other, records from the published literature were summarised by Dunlop et al. (2018), who listed a total of seventeen species. A

further species was added by Kovařík et al. (2020) and a synonym was recognised by Kovařík and Lowe (2022). Here, we aim to expand this baseline data through novel records based on newly collected scorpions belonging to six different species (Fig. 2). We also include an updated summary (Table 1) of species and the states they occur in, as well as the first distribution maps for Sudanese scorpions (Fig. 3), again focussing on the six species for which we have recent and accurate locality data. Four Sudanese scorpion species are thought to be medically significant (see Discussion) and several clinical studies (e.g. Ali and Ali 2015) have reported scorpion stings in this country. Our data may thus be relevant for future public health initiatives, and problems with scorpion envenomation in Sudan are briefly reviewed.

Material and methods

Literature data for Sudanese scorpions was taken from Dunlop et al. (2018), and references therein. We also drew on historical collections held in the Sudan Natural History Museum of the Faculty of Science, University of Khartoum, Khartoum (SNHMK). This material was assembled by several people, mostly from the 1920s through to the 1960s. Unfortunately, the historical data is often associated only with abbreviations for the name of the collector. While some can be inferred based on the literature, for example “D.J.L. (1953)” is almost certainly David J. Lewis who worked in Khartoum in the 1950s, other historical collectors could not be identified unequivocally at this stage and are listed below in the verbatim form from the labels, i.e.: W.C. (1927), R.G.A. (1928), A.E. (1953), M.M.I. (1938), R.C. (1951), A.K.A. (1942), N.M.G. (1947), H.J.M. (1951), and A.M.E. (1952/1960). From the 1990s there is also museum material from J. Nasr Eldin Taj.

Another limiting factor here is that the historical museum data only covers five of Sudan’s eighteen states, namely Khartoum, River Nile, Northern, North Kordofan and North Darfur. To supplement this, new scorpion material was collected by the first (MS) and fourth authors (AM) from a total of eighteen localities across seven states: Northern State (Dongola, Wadi Halfa, Wadi El-Ga’ab, Merawi, Bayood Desert, El-Madeqeen), River Nile State (Atbara, El-Mosawarat, El-Manaseer, Mugrat Island), Kassala (Khashm El-Gerba, Kassala), Khartoum

State (Khartoum, Omdorman), North Kordofan State (El-Obied), White Nile State (Kosti, Ab-Dareesh) and Sennar State (Dinder National Park). Scorpions were detected in the field using ultraviolet detection torches at night, or by searching under surface debris and rocks during the day. Typical habitats/collecting sites for several species are shown in Fig. 1, habitus images of those species for which we have new distribution data in Fig. 2 and the geographical maps were created using ArcMap (version 10.4.1) and are shown in Fig. 3.

Voucher specimens were preserved in 80% ethanol and deposited either in the Sudan Natural History Museum (SNHMK) and/or the Museum für Naturkunde Berlin (MfN) under its traditional acronym ZMB (for ‘Zoologisches Museum Berlin’). Scorpions were initially identified to genus level using available keys, with species identifications mostly confirmed by FK drawing on extensive comparative studies of scorpions from northern and eastern Africa (e.g. Kovařík et al. 2016, 2020).

Results

Of the seventeen scorpion species currently known from the Republic of the Sudan (Dunlop et al. 2018; Kovařík et al. 2020), fifteen belong to the family Buthidae. These are *Androctonus amoreuxi* (Audouin, 1826), *A. australis* (Linnaeus, 1758), *Buthacus leptochelys* (Ehrenberg, 1829), *Buthus brignolii* Lourenço, 2003, *B. duprei* Rossi & Tropea, 2016a, *B. karoraensis* Rossi & Tropea, 2016b,

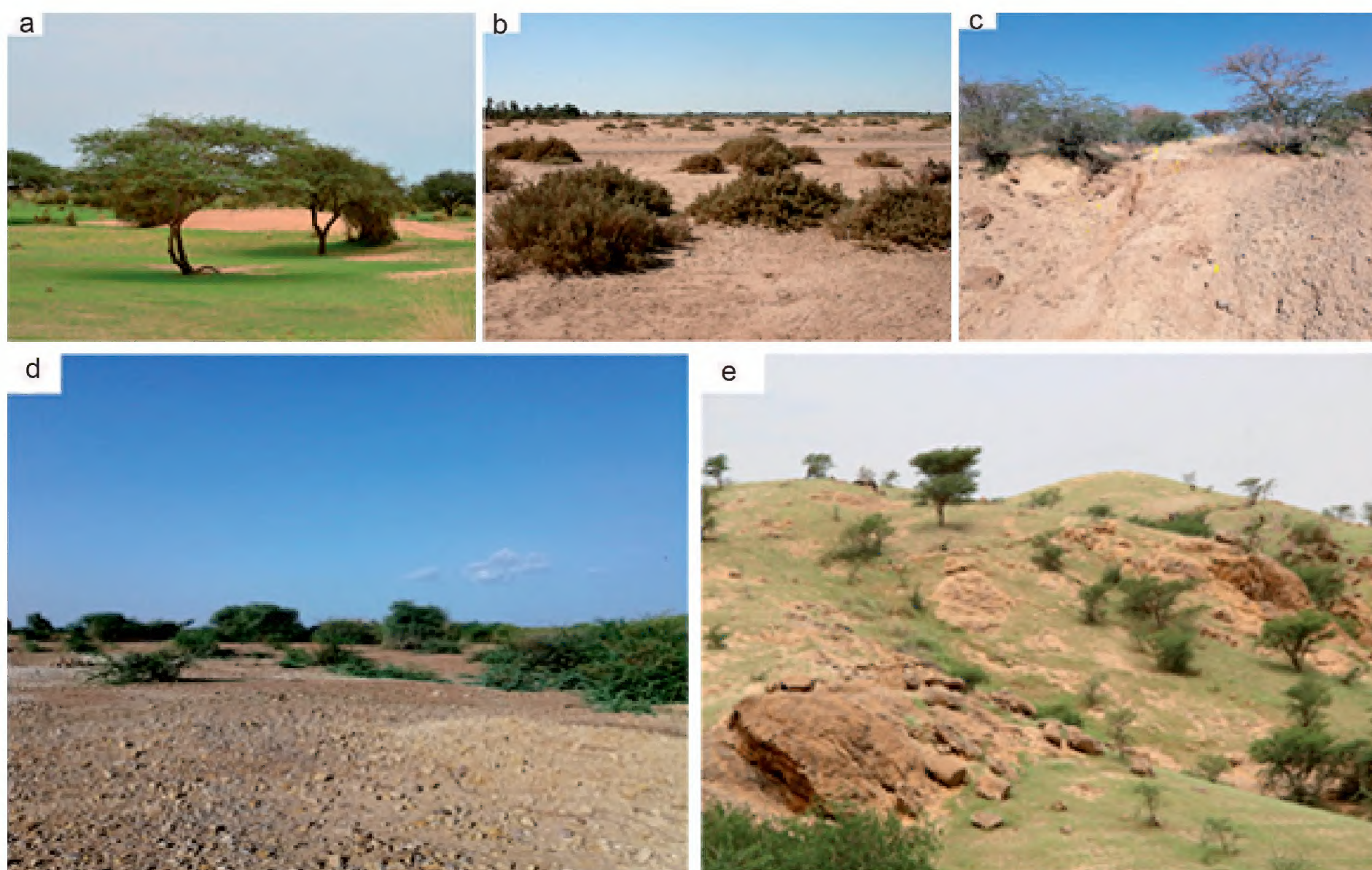


Figure 1. Typical natural habitats for scorpion species in the Republic of Sudan. **a.** Ab-dareesh (White Nile State); **b.** Bayood Desert (Northern State); **c.** Khashm El-Gerba (Kassala State); **d.** Jebel Awliya (Khartoum State); **e.** El-Obeid (North Kordofan State).

Table 1. The seventeen species of scorpion currently known from the Republic of Sudan, cross referenced to the eighteen states, listed approximately from north to south: Northern (NS), River Nile (RNS), Red Sea (RSS), Khartoum (KHS) Kassala (KS), Gezira (GS), North Darfur (NDS), West Darfur (WDS), Central Darfur (CDS), South Darfur (SDS), East Darfur (EDS), North Kordofan (NKS), West Kordofan (WKS), South Kordofan (SKS), White Nile (WNS), Sennar (SS), Al Quadarif (AQS), and Blue Nile (BNS).

	NS	RNS	RSS	KHS	KS	GS	NDS	WDS	CDS	SDS	EDS	NKS	WKS	SKS	WNS	SS	AQS	BNS
BUTHIDAE																		
<i>A. amoreuxi</i>	√			√			√					√						
<i>A. australis</i>	√																	
<i>B. leptochelys</i>	√		√															
<i>B. brignolii</i>							√											
<i>B. duprei</i>			√															
<i>B. karoraensis</i>			√															
<i>C. werner</i>	√	√	√	√	√							√			√	√		
<i>C. seichert</i>				√														
<i>H. minax</i>				√		√							√		√	√		√
<i>H. nilotic</i>												√		√		√		
<i>L. quinquestriatus</i>	√	√		√	√		√								√			√
<i>N. anderson</i>			√															
<i>O. olivaceus</i>	√	√			√													
<i>Pa. hunter</i>		√		√														
<i>Pa. abyssinicus</i>		√		√	√													
SCORPIONIDAE																		
<i>Pnd. sudanicus</i>												√		√				√
<i>Scorpio sudanensis</i>			√															
COUNTS	7	5	6	7	4	1	3	0	0	0	0	4	1	2	3	3	0	3

Compsobuthus werner (Birula, 1908), *C. seichert* Kovařík, 2003, *Hottentota minax* (L. Koch, 1875), *H. niloticus* (Birula, 1928), *Leiurus quinquestriatus* (Ehrenberg, 1828), *Nanobuthus anderson* Pocock, 1895, *O. olivaceus* (Karsch, 1881), *Parabuthus hunter* Pocock, 1895 and *P. abyssinicus* Pocock, 1901. Two more belong to the family Scorpionidae: *Pandinurus sudanicus* (Hirst, 1911a) and *Scorpio sudanensis* Lourenço and Cloudsley-Thompson, 2009. Note that *Orthochirus aristidis* (Simon, 1882) was recently synonymised with *O. olivaceus* (Karsch, 1881) by Kovařík and Lowe (2022), thus the former name has now been removed from the Sudanese species list. In focus in the present study, material assignable to six of these buthid species was collected during the present study and includes several novel state and/or locality records. These are detailed below and summarised in Table 1 and the distribution maps.

Family Buthidae C.L. Koch, 1837
Genus Androctonus Ehrenberg, 1828

***Androctonus amoreuxi* (Audouin, 1826)**

Figure 2a

Material examined. 1♂ 1♀; SNHMK 2.334, SNHMK 2.337, The Republic of Sudan, North Kordofan State, Abu Zabad (12°21'25.4"N, 29°13'40.2"E, 577 m a.s.l), leg. N.M.G. 28.7.1947., det. N.M.G., leg. A.M.E. 6.1952., det. A.M.E. 1♂ 1♀; SNHMK 2.333, North Darfur State, Abu Sufyan (11°55'25.4"N, 26°22'41.2"E, 499 m a.s.l), leg. H.J.M. 1951, det. H.J.M. 1♀ SNHMK 2.331, Northern State, Gureir (18°20'03.0"N, 31°45'22.0"E, 254 m a.s.l),

leg. J.W. C., 10.1.1939, det. J.W. C. 1♂ 1♀; ZMB 49413–414, Merawi (18°30'06.7"N, 31°48'15.3"E, 279 m a.s.l), leg. A. Mohammad, 29.05.2011, det. A. Mohammad and F. Kovařík. 1♂ 1♀; SNHMK 2.547, Northern State, El Madeqeen – Sa’ad Finti, (20°20'18.96"N, 30°33'38.23"E, 789 m a.s.l), 15.03.2021, leg. H. Marzoug, det. M. Siyam. 1♂; ZMB 49415, Khartoum State, West Omdurman (15°40'59.6"N, 32°14'56.9"E, 428 m a.s.l), leg. A. Mohammad, 25.07.2011, det. A. Mohammad and F. Kovařík.

Description. Male/female total body length (8–10 cm). General coloration yellow. Prosoma yellowish brown, with dark yellow granulated carinae. Mesosoma light brown, tergites granulated over whole surface. Metasoma thick, yellow, except for segment V which is light brown. Telson with two yellowish vertical bands on ventral side; aculeus tip black. Legs yellowish brown. Pedipalps long and brownish orange; manus slightly swollen. Pectines with 21–25 teeth in females and 31–35 teeth in males.

Remarks. *Androctonus amoreuxi* is found in the arid north of Sudan, usually in sandy areas. Like *L. quinquestriatus* (see below), it is highly venomous and aggressive (Soliman et al. 2013). Limited work has been done on the distribution of *Androctonus amoreuxi* and the related species *A. australis* in Africa. They have almost the same general morphology and coloration. However, *A. australis* has wider metasomal segments associated with spinoid granule rows and a dorsal depression in addition to strongly developed dorsal carinae on metasomal segments I to IV and three well developed lateral lobes in an anal arc (Seiter and Turiel 2013). *A. amoreuxi* was previously documented by Hemprich and Ehrenberg (1828) and Birula (1908) from two localities in Northern State:

Dongola and Wadi Halfa. The present discovery in Merwi, Gureir and El Madeqeen – Sa'ad finti (also Northern State) represent new locality records, while its occurrence in west Omdorman (Khartoum State), Abu Zabad (North Kordofan State) and Abu Sufyan (North Darfur State) represent three new state and locality records.

Genus *Buthacus* Birula, 1908

Buthacus leptochelys (Ehrenberg, 1829)

Figure 2b

Material examined. 2♀; ZMB 49416–417, The Republic of Sudan, White Nile State, Ab-Dareesh (14°59'31.9"N, 32°26'49.8"E, 384 m a.s.l), 12.05.2013, leg. A. Mohamad, det. F. Kovařík. 1♀ 1♂ juv., Kovařík collection, The Republic of Sudan, Northern State, Kawa, 19°6'29.24"N, 30°30'25.07"W, XI.2013, leg. V. Trailin; Khenifra, IV.2015, leg. V. Trailin.

Description. Female total body length (5–7 cm). General coloration dark orange. Prosoma yellowish brown. Mesosoma dark orange, carinae on tergites almost absent. Metasoma orange except segment I which is darker and segment V which is more orange with granules on the retrolateral sides. Telson yellow, aculeus long with black tip. Legs yellowish brown. Pedipalps brownish orange and long. Pectines with 24 teeth in females and 30–31 in males.

Remarks. This species, which may in future need to be divided into several species, was first described by Hemprich and Ehrenberg (1828) and Ehrenberg (1829) as *Androctonus (Leiurus) leptochelys*. The status of the genus *Buthacus* was confusing, but has recently been subject to several revisions (e.g. Kovařík 2018; Cain et al. 2021). *Buthacus leptochelys* was previously recorded in Dongola (Northern State), Duroor and Port Sudan (Red Sea State). Here, it is recorded for the first time in White Nile State, specifically from the locality of Ab-Dareesh and from further localities near Dongola.

Genus *Compsobuthus* Vachon, 1949

Compsobuthus wernerii (Birula, 1908)

Figure 2c

Material examined. 1♀; ZMB 48709, The Republic of Sudan, Red Sea State, Erkeet, Jebel El-sitt (18°47'49.0"N, 37°06'44.0"E, 1084 m a.s.l), leg. M. Siyam, 06.10.2011, det. F. Kovařík. 1♀; 2.550, Northern State, El Madeqeen – Kouya (20°20'25.512"N, 30°24'17.748"E, 685 m a.s.l), 10.08.2021, leg. H. Marzoug, det. M. Siyam. 1♂ 1♀; ZMB 49494, Northern State, Dongola (19°08'38.8"N, 30°28'51.6"E, 228 m a.s.l), leg. M. Siyam, 07.06.2016, det. F. Kovařík. 1♂ 1♀; ZMB 49448, ZMB 49493, Northern State, Wadi El-Ga'ab (19°27'47.5"N, 30°15'23.3"E, 219 m a.s.l), 15.09.2019, leg. I, Al-Khidir, det. M. Siyam. 1♀; SNHMK 2.306, North Kordofan State, El-Obeid – Tagat (13°04'26.0"N, 30°20'44.2"E, 600 m a.s.l), leg. M. Siyam, 14.9.2018, det. F. Kovařík. 1♂ 1♀; SNHMK

2.311, SNHMK 2.310, White Nile State, Kosti – a farm (13°09'39.4"N, 32°40'59.2"E, 385 m a.s.l), leg. M. Siyam, 17.09.2018, det. F. Kovařík. 4♀; ZMB 49440–443, Kassala State, Muraba'a village – Berno Wadi (14°16'45.8"N, 35°52'36.1"E, 502 m a.s.l), leg. M. Siyam and O. Khalil, 14–19.02.2019, det. M. Siyam.

Description. Male / female total body length (5–6 cm). General coloration pale brown. Prosoma light brown with darker carinae. Mesosoma brown with granulated tergites except VII with lighter coloration. Metasoma yellowish brown, thin and ventral surface granulated with vertical black bands. Telson bulbous, brown, aculeus shorter than vesicle; tip black. Legs yellow. Pedipalps medium yellowish brown, manus slightly swollen. Pectines with 17 teeth in females and 20 teeth in males.

Remarks. *Compsobuthus* is one of the most widely distributed genera of the family Buthidae with records from the Republic of Sudan, Ethiopia and Somaliland as the south-eastern limits of distribution for this genus (Kovařík et al. 2016a). Despite its small body size, *Compsobuthus wernerii* is a fairly toxic species, usually found under stones or embedded in sand or underground. It was previously documented from several localities in the Republic of Sudan (see Dunlop et al. 2018) and its range is here expanded to include four new localities representing three new states (North Kordofan, White Nile and Kassala).

Genus *Leiurus* Ehrenberg, 1828

Leiurus quinquestriatus (Ehrenberg, 1829)

Figure 2d

Material examined. 1♀; SNHMK 2.316, The Republic of Sudan, River Nile State, Shendi (16°40'15.6"N, 33°26'59.6"E, 363 m a.s.l), leg. J.W. C., 26.12.1927, det. J.W. C. 1♂ 1♀; ZMB 49463, ZMB 49462, Northern State, Ambucol (21°18'15.6"N, 30°53'13.9"E, 182 m a.s.l), 26.10.2012, leg. A. Mohammad, det. A. Mohammad. 1♂ 1♀; ZMB 50601, Northern State, Bayood Desert, (19°32'42.9"N, 30°30'47.9"E, 224 m a.s.l), 03.09.2012, leg. A. Mohamed, det. A. Mohammad. 1♂; ZMB 49466, Northern State, Merawi (18°30'06.7"N, 31°48'15.3"E, 279 m a.s.l), 25.08.2005, leg. A. Mohamed, det. A. Mohammad. Northern State, 1♂ 1♀; SNHMK 2.548, El Madeqeen – Sa'ad Finti, (20°20'18.96"N, 30°33'38.23"E, 789 m a.s.l), 15.03.2021, leg. H. Marzoug, det. M. Siyam. 1♀; ZMB 49467, White Nile State, Ab-Dareesh (14°59'31.9"N, 32°26'49.8"E, 384 m a.s.l), 11.05.2012, leg. A. Mohammad. det. A. Mohammad. 2♀; SNHMK 2.346, North Darfur State, Kuma District, Hajar Elsari (13°57'04.0"N, 26°01'39.0"E, 745 m a.s.l), 30.07.2012, leg. (unknown), det. M. Siyam. 1♀; SNHMK 2.302, Northern State, Kerma (19°38'27.0"N, 30°35'01.0"E, 223 m a.s.l), 09.10.2016, leg. O. Abubakr, det. M. Siyam. 1♂ 1♀; ZMB 49461, ZMB 49460, Northern State, Wadi El-Ga'ab, (19°27'47.5"N, 30°15'23.3"E, 219 m a.s.l), 15.09.2019, leg. I, Al-Khidir, det. M. Siyam. 1♀; SNHMK 2.303, River Nile State, El-Mosawarat (16°16'08"N,



Figure 2. Habitus photographs of several Sudanese scorpion species, all in the family Buthidae, for which we can offer new distribution data here. **a.** *Androctonus amoreuxi* (Audouin, 1826); **b.** *Buthacus leptochelys* (Ehrenberg, 1829); **c.** *Compsobuthus wernerii* (Birula, 1908); **d.** *Leiurus quinquestriatus* (Ehrenberg, 1829); **e.** *Orthochirus olivaceus* (Karsch, 1881); **f.** *Parabuthus abyssinicus* (Pocock, 1901). Of these, *A. amoreuxi*, *L. quinquestriatus* and *P. abyssinicus* have a potent venom and are regarded as medically significant.

33°16'36"E, 424 m a.s.l), leg. I. Al-Khidir, 06.12.2018., det. M. Siyam. 2♀; SNHMK 2.360, River Nile State, Murgat Island (19°30'00.0"N, 33°15'00.0"E, 317 m a.s.l), leg. O. Khalil, 03.02.2018. det. M. Siyam, 1♀; ZMB 49465, River Nile State, El-Manaseer, Birti (16°16'08.0"N, 33°16'36.0"E, 424 m a.s.l) leg. M. Bakhit, 07.08.2019. det. M. Bakhit. 2 (juv); ZMB 49422, Kassala State, Khashm

El-Gerba - Muraba'a village – Berno Wadi (14°16'45.8"N, 35°52'36.1"E, 502 m a.s.l), leg. M. Siyam and O. Khalil, 14–19.02.2019, det. M. Siyam and F. Kovařík.

Description. Male/ female total body length (9–13 cm). General coloration yellow to brownish yellow, depending on region. Prosoma yellowish brown, with brownish granulated carinae. Mesosoma brown, tergites granulated

all over (I–VI darker than VII). Metasoma yellow, except segment V which is dark brown; tip of telson black. Legs pale yellow. Pedipalps long and yellow; manus normal. Pectines with 28 teeth in females and 36–37 teeth in males.

Remarks. *Leiurus quinquestriatus* is a widely distributed species both in Sudan and northern Africa through into the Middle East. It is typically found in poor savanna areas or mountains, usually under stones or shrubs. This species is highly toxic and aggressive and is known to cause fatalities, especially among children (Ali and Ali 2015). Our present material documented above represents four new state records (Kassala, River Nile, White Nile and North Darfour State) and thirteen new locality records for this species.

Genus *Orthochirus* Karsch, 1892

Orthochirus olivaceus (Karsch, 1881)

Figure 2e

Material examined. 1♂1♀; SNHMK 2.535, SNHMK 2.536, River Nile State, El-Manaseer, Birti (18°58'03.7"N, 32°21'32.5"E, 306 m a.s.l) leg. M. Bakheet, 11.08.2019. det. F. Kovařík. and M. Siyam. 1♂; ZMB 49428, Northern State, Wadi El-Ga'ab, (19°27'47.5"N, 30°15'23.3"E, 219 m a.s.l), 15.09.2019, leg. I. Al-Khidir, det. F. Kovařík. 1♀ SNHM 2.549, Northern State, El Madeqeen – Kouya (20°20'25.512"N, 30°24'17.748"E, 685 m a.s.l), 10.08.2021, leg. H. Marzoug, det. M. Siyam. 1♀; ZMB 48708, The Republic of Sudan, Kassala State, Near Jebel Taka (15°26'01.0"N, 36°25'19.0"E, 510 m a.s.l), leg. M. Siyam, 04.10.2011, det. F. Kovařík.

Description. Total body length (3–5 cm). General coloration black. Prosoma black with granules. Mesosoma black with thickly granulated tergites. Metasoma black, thick and granulated. Telson entirely black. Legs pale yellow. Pedipalps bicoloured; femur and patella dark brown, manus long and yellow. Pectines with 15–20 teeth in females and 15 teeth in males.

Remarks. Karsch (1892) first recognised the genus *Orthochirus*, but its constituent taxa remained neglected for many years. Part of the problem was that the original locality for the type species of the genus given by Karsch (1881), Sicily in Italy, is almost certainly erroneous (discussed by Kovařík et al. 2020) and *Orthochirus olivaceus* is, in fact, a North African scorpion. This species was described for the first time in Sudan by Kovařík et al. (2020) from Wadi Halfa in and Wadi El-Ga'ab (both Northern State). Here we offer three new localities and two states: El-Manaseer, Birti (River Nile State), Kassala (Kassala State) and El Madeqeen – Kouya (Northern State).

Genus *Parabuthus* Pocock, 1890

Parabuthus abyssinicus (Pocock, 1901)

Figure 2f

Material examined. 1♀; ZMB 48710, The Republic of Sudan, Red Sea State, Toker (18°32'27.0"N, 37°49'10.0"E, 25 m a.s.l), leg. M. Siyam. 09.10.2011.

det. F. Kovařík. 1♀; ZMB 49430, Kassala State, Kassala – El-Gash (15°26'58.8"N, 36°23'21.0"E, 508 m a.s.l), leg. M. Mustafa 26.12.2019., det. M. Siyam and F. Kovařík. 2♂; ZMB 49431–432, Kassala State, Khashm El-Gerba, Muraba'a village – Berno Wadi (14°16'45.8"N, 35°52'36.1"E, 502 m a.s.l), leg. M. Siyam and O. Khalil, 14–19.02.2019, det. M. Siyam and F. Kovařík.

Description. Male/female total body length (7–9 cm). General coloration brown. Prosoma brown; lighter in front. Mesosoma dark brown, with slightly granulated tergites except VII with lighter coloration and thick granulation. Metasoma thick and strongly granulated, segments I–III dark yellow while segments IV and V dark brown. Telson reddish brown, aculeus tip black. Legs yellowish brown. Pedipalps long, yellowish brownish, manus normal. Pectines with 33 teeth in females and 40 teeth in males.

Remarks. *Parabuthus* is a poorly documented genus in the horn of Africa, and the Republic of Sudan represents the northern limits of its distribution (Kovařík et al. 2016b). *Parabuthus abyssinicus* was, for many years, treated as a synonym of *P. liosoma* Ehrenberg 1828 before being revalidated by Kovařík et al. (2016b) as part of a species complex. *P. abyssinicus* is a highly venomous and aggressive species (e.g. Cilli and Corazzi 1946), usually found in sandy areas or under stones or wood. King (1925) documented it, as *P. liosoma*, in Khartoum (Khartoum State) and Erkowit (Red Sea State). The new specimens of *P. abyssinicus* now added a new locality record (Toker) from Red Sea State and new state record (Kassala State) in with two new localities (Kassala and Khashm Elgerba).

Discussion

Four of the scorpion species found in Sudan have highly potent venom and are thus regarded as medically significant: *Androctonus amoreuxi*, *A. australis*, *Leiurus quinquestriatus* and *Parabuthus abyssinicus*. For accounts of these species' toxicity, also in neighbouring countries, see Cilli and Corazzi (1946), Adi-Bessalem et al. (2008), Goyffon et al. (2012), Soliman et al. (2013) and Ali and Ali (2015). The two *Androctonus* species, colloquially known as 'fat-tailed scorpions', were previously known only in Sudan from Northern State in the north of the country (Dunlop et al. 2018). In the present study the range of at least *Androctonus amoreuxi* can be expanded to the south (Table 1, Fig. 3) to include the three adjacent states of North Darfur, North Kordofan and Khartoum. *Leiurus quinquestriatus*, the 'deathstalker' or 'Omdurman scorpion', has a wider distribution (Fig. 3). It has been recorded in Sudan from seven states, even down as far as Blue Nile State in the south of the country; whereby four state records (Kassala, River Nile, White Nile and North Darfur) could be added in the present study. Both King (1925) and Abushama (1961) noted that this species is quite common in north–central Sudan, and

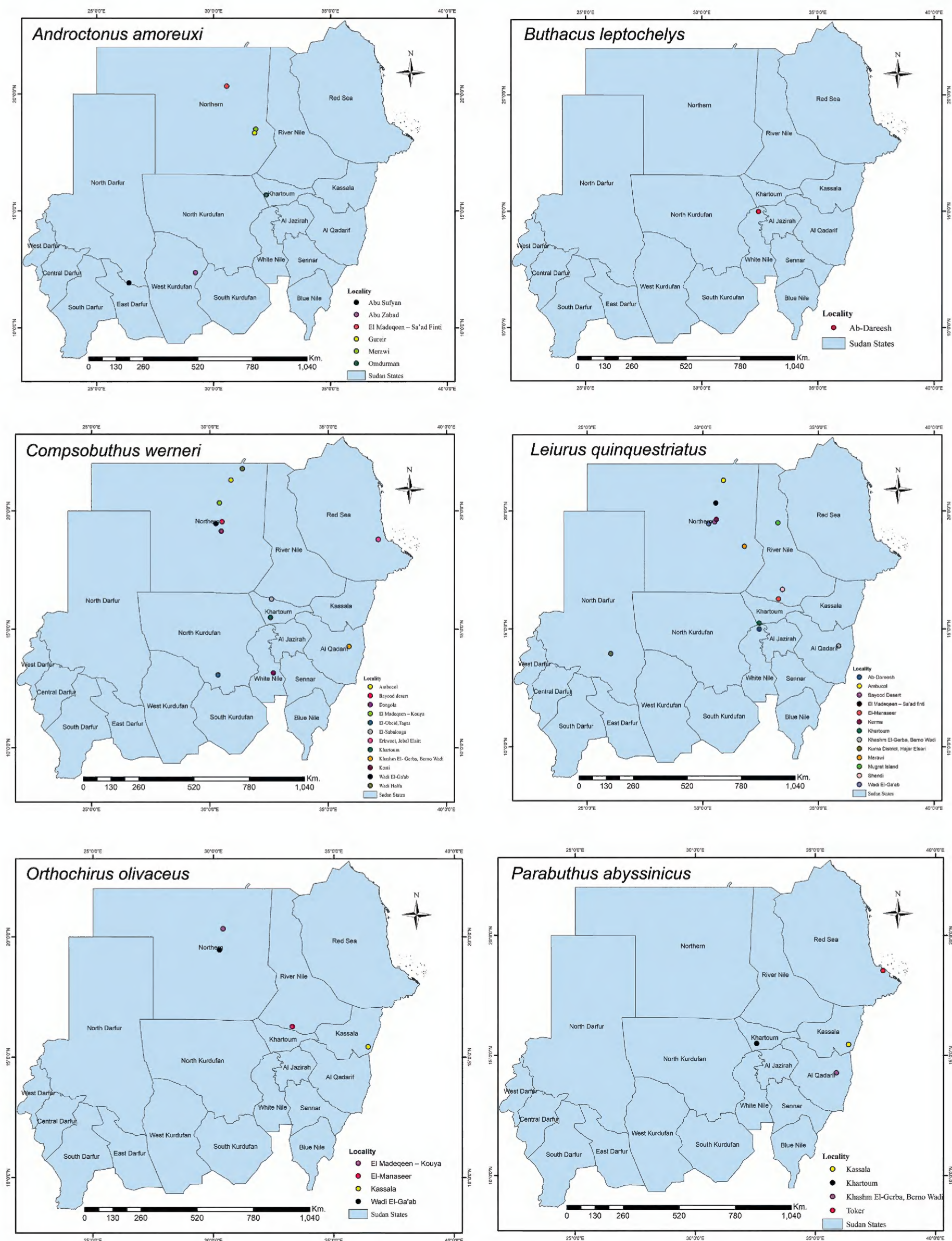


Figure 3. Distributions of the scorpion species *Androctonus amoreuxi* (Audouin, 1826), *Buthacus leptochelys* (Ehrenberg, 1829), *Compsobuthus werner* (Birula, 1908) *Leiurus quinquestriatus* (Ehrenberg, 1829), *Orthochirus olivaceus* (Karsch, 1881) and *Parabuthus abyssinicus* (Pocock, 1901) (all Buthidae) in the Republic of Sudan based on present data and the published literature. As in Fig. 2, *A. amoreuxi*, *L. quinquestriatus* and *P. abyssinicus* are regarded as medically significant.

we might expect further records from other parts of the country. *Parabuthus abyssinicus* is restricted to eastern Sudan and a new state record (Kassala) was added here (Fig. 3).

While there are several published clinical case studies about scorpion stings from Sudan, the authors were, unfortunately, often unable to identify the species involved. For example, Elmadhoun and Hussain (2011)

offered hospital data (including fatalities in children) for the Atbara region in River Nile State, although none of the potentially dangerous species noted above had been previously recorded here. Our data shows that *Leiurus quinquestriatus* occurs in River Nile State too (Fig. 3), and thus may have been the scorpion responsible for some or all of the hospitalisations. A similar problem affects the otherwise useful summary of Ali and Ali (2015). Their fig. 4 shows a concentration of reported scorpion stings along the Nile valley, but this may just reflect higher population densities. The respondents to their survey were also not in a position to provide useful data about which scorpion(s) were responsible, beyond reporting them as being black (perhaps *Hottentotta* or *Orthochirus*?) or more commonly yellow, which could, of course, refer to several possible species. Thus, it is essential to provide basic diagnostic characters (combining colour, size, habitus, etc.) for the different scorpion species and make these available to clinicians, and the general public, so that they can both recognise and avoid the most venomous taxa. This will hopefully lead to better data on the distribution and habitats of the most dangerous scorpions.

The highest diversity of scorpions in general (according to Table 1) is in Khartoum and Northern States (both have 7 species), Red Sea States (6 species), River Nile and Kassala states (5 species); see also Fig. 3. We suspect that this may be more due to the proximity to population centres like Khartoum where previous zoologists were active (e.g. King 1925) and/or historical collecting activity which focussed on sites like Dongola and Wadi Halfa in the north near the Egyptian border (Hemprich and Ehrenberg 1828) and the Suakin and Port Sudan regions near the Red Sea. Significant gaps exist in the Darfur region (Fig. 3) making up the west of Sudan, for which we could newly record *Androctonus amoreuxi* (see above) as one of only three scorpion species known from North Darfur. The five Darfur states have proved difficult to sample due to ongoing political instability and the rarity of historical field trips. As shown in Table 1, the states of East, Central, South and West Darfur have no recorded scorpions to date despite the semi-arid climate here being suitable for several species. This large, but neglected, region may offer new species or records for scorpions and other arachnids in Sudan. Fieldwork here is likely to be very productive.

Acknowledgements

We thank Othman Khalil, Muhajer Mustafa, Samah Makawi, Intesar Al-Khidir, and Mohamed Bakhit for help with field collection, Anja Friederichs (Berlin) for curatorial assistance, and Abd Elmajeed El-Rasheed and Yousif El-Obeid from the Department of Geology for designing the geographical maps. Victor Fet and an anonymous reviewer provided helpful comments on a previous version of the typescript.

References

- Abushama FT (1961) Some aspects of the biology of *Leiurus quinquestriatus* (H and E): A common scorpion species in the central Sudan. M.Sc. Thesis, Faculty of Science, University of Khartoum.
- Adi-Bessalem S, Hammoudi-Triki D, Laraba-Djebari F (2008) Pathophysiological effects of *Androctonus australis hector* scorpion venom: Tissue damages and inflammatory response. *Experimental and Toxicologic Pathology* 60(4–5): 373–380. <https://doi.org/10.1016/j.etp.2008.03.006>
- Ali NOM, Ali NOM (2015) Scorpion sting in different regions of Sudan: Epidemiological and clinical survey among university students. *International Journal of Bioinformatics and Biomedical Engineering* 1: 147–152.
- Audouin V (1826) Planche 8. Scorpions, Pisces, Solifuge. In: Explication sommaire des planches d'Arachnides del'Égypte et de la Syrie, publiées par J.-C.Savigny. Description de l'Égypte, ou recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française. Histoire naturelle, 1. Paris: C.L.P. Panekoucke 22: 172–174.
- Birula AA (1908) Ergebnisse der mit Subvention aus der Erbschaft Treutl unternommenen zoologischen Forschungsreise Dr. F. Werner's nach dem Ägyptischen Sudan und Nord-Uganda. XIV. Skorpiones und Solifugae. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien – mathematisch-naturwissenschaftliche Classe* 117: 121–152.
- Birula AA (1928) Wissenschaftliche Ergebnisse der mit Unterstützung der Akademie der Wissenschaften in Wien aus der Erbschaft Treutl von F. Werner unternommenen Zoologischen Expedition nach dem Anglo-Ägyptischen Sudan (Kordofan) 1914. XXV. Skorpione. *Denkschriften der Akademie der Wissenschaften in Wien* 101: 79–88.
- Borelli A (1929) Scorpions du Soudan. *Annals & Magazine of Natural History* 10(3): 297–300. <https://doi.org/10.1080/00222932908672973>
- Cain S, Gefen E, Prendini L (2021) Systematic revision of the sand scorpions, genus *Buthacus* Birula, 1908 (Buthidae CL Koch, 1837) of the Levant, with redescription of *Buthacus arenicola* (Simon, 1885) from Algeria and Tunisia. *Bulletin of the American Museum of Natural History* 450(1): 3–133. <https://doi.org/10.1206/0003-0090.450.1.1>
- Cilli V, Corazzi G (1946) Venoms of Eritrean scorpions, *Parabuthus liosoma abyssinicus* and *Pandinus magretti*. Preparation of specific antivenenes. *Bollettino della Società Italiana di Medicina e Igiene Tropicale. Sezione Eritrea* 6(6): 397–406.
- Dunlop JA, Siyam M, Kovařík F (2018) Smaller orders of Arachnida in Sudan: A literature review. *Arachnology* 17(9): 449–457. <https://doi.org/10.13156/arac.2018.17.9.449>
- Elmadhoun WMY, Hussain O (2011) Common causes of child mortality in Atbara teaching hospital, Sudan. *Gezira Journal of Health Sciences* 7(1): 45–50.
- Ehrenberg CG (1829) Vorläufige Uebersicht der in Nord-Afrika und west-Asien einheimischen Skorpione und deren geographischen Verbreitung. *Verhandlung der Gesellschaft Naturforschende Freunde in Berlin* 1(6): 348–362.
- Goyffon M, Dabo A, Coulibaly SK, Togo G, Chippaux JP (2012) Dangerous scorpion fauna of Mali. *The Journal of Venomous Animals and Toxins Including Tropical Diseases* 18(4): 361–368. <https://doi.org/10.1590/S1678-91992012000400003>

- Hemprich FW, Ehrenberg CG (1828) Zoologica II. Arachnoidea. In: CG Ehrenberg (Ed.) Symbolae Physicae seu Icones et Descriptiones Animalium Evertibratorum Sepositis Insectis quae ex Itinere per Africam Borealem et Asiam Occidentalem. Friderici Guilelmi Hemprich et Christiani Godofredi Ehrenberg, Medicinae et Chirurgiae Doctorum, Studio Novae aut Illustratae Redierunt. Percensuit et Regis Iussu et Impensis. Decas Prima. Mittlerer: Berolini. [plate I Buthus; plate II: Androctonus]
- Hirst S (1911a) Scorpions and solifugae collected by Captain S. S. Flower in the Anglo-Egyptian Sudan. Annals & Magazine of Natural History 8(7): 217–222. <https://doi.org/10.1080/00222931108692928>
- Hirst S (1911b) Descriptions of new scorpions. Annals & Magazine of Natural History 8(8): 462–473. <https://doi.org/10.1080/00222931108693056>
- Karsch F (1881) Uebersicht der europäischen Skorpione. Berliner Entomologische Zeitschrift 25(1): 89–91. <https://doi.org/10.1002/mmnd.18810250114>
- Karsch F (1892) Arachniden von Ceylon und von Minikoy gesammelt von den Herren Doctoren P. und F. Sarasin. Berliner Entomologische Zeitschrift 36: 267–310. <https://doi.org/10.1002/mmnd.47918920112>
- King HH (1925) Notes on Sudan scorpions. Sudan Notes and Records 8: 79–84.
- Koch CL (1837) Uebersicht des Arachnidensystems. Nürnberg. C. H. Zeh'sche Buchhandlung 1: 1–39. <https://doi.org/10.5962/bhl.title.39561>
- Koch L (1875) Aegyptische und Abyssinische Arachniden: gesammelt von Herrn C. Jickeli beschrieben und abgebildet. Nürnberg, 96 pp. <https://doi.org/10.1002/mmnd.48018750239>
- Kovářík F (2003) Eight new species of *Compsobuthus* Vachon, 1949 from Africa and Asia (Scorpiones: Buthidae). Serket 8: 87–112.
- Kovářík F (2018) Notes on the genera *Buthacus*, *Compsobuthus*, and *Lanzatus* with several synonymies and corrections of published characters (Scorpiones: Buthidae). Euscorpius 269(269): 1–12. <https://doi.org/10.18590/euscorpius.2018.vol2018.iss269.1>
- Kovářík F, Lowe G (2022) Scorpions of the Horn of Africa (Arachnida, Scorpiones). Part XXVIII. Scorpions of Djibouti. Euscorpius 357: 1–31. <https://doi.org/10.18590/euscorpius.2017.vol2017.iss243.1>
- Kovářík F, Lowe G, Plišková J, Štáhlavský F (2016a) Scorpions of the Horn of Africa (Arachnida: Scorpiones). Part VI. *Compsobuthus* Vachon, 1949 (Buthidae), with a description of *C. eritreaensis* sp. n. Euscorpius 226(226): 1–21. <https://doi.org/10.18590/euscorpius.2016.vol2016.iss226.1>
- Kovářík F, Lowe G, Plišková J, Štáhlavský F (2016b) Scorpions of the Horn of Africa (Arachnida: Scorpiones). Part VII. *Parabuthus* Pocock, 1890 (Buthidae), with description of *P. hamar* sp. n. and *P. kajibu* sp. n. from Ethiopia. Euscorpius 228: 1–58. <https://doi.org/10.18590/euscorpius.2016.vol2016.iss228.1>
- Kovářík F, Fet V, Siyam M (2020) Taxonomic position of *Orthochirus olivaceus* (Karsch, 1881), the type species of the genus *Orthochirus* Karsch, 1892 (Scorpiones: Buthidae). Euscorpius 319: 1–15. <https://doi.org/10.18590/euscorpius.2019.vol2019.iss296.1>
- Lourenço WR (2003) Compléments à la faune de scorpions (Arachnida) de l'Afrique du Nord, avec des considérations sur le genre *Buthus* Leach, 1815. Revue Suisse de Zoologie 110: 875–912. <https://doi.org/10.5962/bhl.part.80218>
- Lourenço WR, Cloudsley-Thompson JL (2009) A new species of the genus *Scorpio* Linnaeus 1758 from Sudan (Scorpiones, Scorpionidae). Boletín de la SEA 45: 123–126.
- Pocock RI (1890) A revision of the genera of scorpions of the family: Buthidae, with descriptions of some South-African species. Proceedings of the Zoological Society 1890: 114–141.
- Pocock RI (1895) Supplementary note on the scorpions obtained in Egypt and the Soudan by Dr. John Anderson F. R. S. Journal of the Linnaean Society. Zoology 25: 299–312. <https://doi.org/10.1111/j.1096-3642.1895.tb03419.x>
- Pocock RI (1901) On a new species of the genus *Parabuthus*. Bollettino dei Musei di Zoologia dell'Università di Torino 16(382): 1.
- Rossi A, Tropea G (2016a) A complementary study on the genus *Buthus* Leach, 1815 in Sudan with the description of a new species (Scorpiones: Buthidae). Rivista Aracnologica Italiana 8: 24–31.
- Rossi A, Tropea G (2016b) On the presence of the genus *Buthus* Leach, 1815 in Sudan with the description of a new species from the enclave of Karora (Scorpiones: Buthidae). Onychium 12: 3–10.
- Seiter M, Turiel C (2013) First record of *Androctonus australis* (Linnaeus, 1758) from Jordan (Scorpiones: Buthidae). Revista Iberica de Aracnologia 23: 95–98.
- Simon E (1882) Étude sur les Arachnides de l'Yemen méridionale. Viaggio as Assab nel Mar Rosso, dei Signori G. Doria ed O. Beccari con il R Avviso 'Esploratore' dal 16 nov. 1879 al 26 feb 1880. Annali del Museo Civico di Storia Naturale di Genova 18: 207–260.
- Soliman BA, Shoukry NM, Mohallal ME, Fetaih HA, Khaled HS (2013) Fine structure of the stinger, histology and histochemistry of the venom gland in the scorpion *Androctonus amoreuxi* (Buthidae). Journal of Basic & Applied Zoology 66(2): 41–46. <https://doi.org/10.1016/j.jobaz.2013.03.001>
- Vachon M (1949) Études sur les Scorpions. III (Suite). Description des scorpions du Nord de l'Afrique. Archives de l'Institut Pasteur d'Algérie 27: 66–100.
- Werner F (1911) Scorpions and annulated spiders of the Anglo-Egyptian Sudan. Fourth Report of the Wellcome Tropical Research Laboratories at the Gordon Memorial College Khartoum, Volume B – General Science: 179–194.